Near infrared spectroscopy predictions on heterogeneous databases: an example of plants from sub-alpine meadows and shrublands

Lembke, M. [a, c]; Bastianelli, D. [b, *]; Dobremez, J-F. [c]; Hervouet, C. [b]; Bonnal, L. [b] and Maillard, D. [a]

[a] *ONCFS, CNERA faune de montagne, Montpellier, France*

[b] *CIRAD, Laboratoire d'Alimentation Animale, TA 30/A Baillarguet, 34398 Montpellier Cedex 5, France*

[c] *Université de Savoie, LECA – TDE, Le Bourget-du-Lac, France*

** Corresponding author, E-mail: denis.bastianelli@cirad.fr*

Keywords: Ibex, feed resources, chemical composition, NIR spectroscopy

Introduction

The aim of this study was to describe the diet of the wild European mountain goat (*Capra i. ibex*), through a characterization of the vegetation of the habitat where the animals roam. The sub-alpine vegetation is composed of a high number of species, forming a heterogeneous cover [1]. This cover constitutes a highly variable diet resource for *C. i. ibex*. As the diet selection of *C. i. ibex* in the study site is largely unknown, the objective of this study was to assess the nutritional quality of the plant cover through its chemical composition.

Materials and methods

A total of 500 plant samples were collected from various places throughout the study zone over a two year period. A total of 91 identified plant species were present in the plant samples making it impossible to establish one NIR spectroscopic calibration for each individual plant species.

Each sample was oven dried at 60°C and ground to pass through a 1mm sieve. The chemical composition of between 150 and 200 samples, selected to spectrally represent the whole database, were measured. Crude protein (CP) was measured by the Kjeldahl method, acid detergent lignin (ADL) was measured by the Van Soest method [2] and *in vitro* organic matter digestibility (OMD) was measured using pepsin and cellulase.

Spectra were collected in reflectance mode in duplicate, with two different cup fillings, using a Foss 6500 spectrometer with a spinning sample module (Foss NIRSystems, Silver Spring, MD, USA) and averaged.

Calibration equations were built after mathematical pre-processing of data using the standard normal variate (SNV) and detrend procedure on the second derivative spectra. Visible wavelengths were discarded because they introduced instability in models. Models containing visible wavelengths had lower standard errors of calibration (SEC) but higher standard errors of cross-validation (SECV). Partial least squares (PLS) regression was found to be the most efficient method for calibration. Data were processed with the modified PLS procedure of WinISI software (Win-ISI, Infrasoft International, Port Matilda, PA, USA).

Results and discussion

General equations based on the whole database had SECV values of 0.52% for CP, 1.37% for ADL and 2.73% for OMD, leading to high ratios of performance to deviation (RPD standard deviation of the population divided by the SECV) of 7.7, 6.1 and 5.2 respectively due to the high variability of the population.

The choice of computing general equations can be questioned since plant cover can be roughly split into two distinct categories, herbaceous plants and shrubby plants, which differ strongly in terms of their chemical composition and nutritional value. It was therefore decided to split the database according to these categories and generate different equations for the two types of plant cover.

Samples were allocated to a category on the basis of their known botanical composition. Some samples could not be classified *a priori*. A factorial discriminant analysis was performed on spectral data for samples of known category, and the discriminant equation applied to unknown samples to classify them. Calibrations were then run for each of the two types of plant cover separately. SECV values for CP, ADL and OMD were 0.50%, 1.43%, 3.43% respectively for the herbaceous plants and 0.44%, 1.30%, 2.42% respectively for the shrubby plants.

Conclusion

NIR spectroscopy analysis was shown to be an efficient tool to predict the composition of our heterogeneous plant database as described previously by Thuriès *et al*. [3]. NIR spectra were also useful for classifying the samples according to whether they were of an herbaceous or shrubby type. Splitting the database into these categories did not improve predictions significantly, suggesting that calibrations based on the whole dataset could be used with confidence to predict the nutritive value of a heterogeneous botanical community consisting of herbaceous and shrubby plants.

References

1. M. Lembke, *L'habitat alimentaire du bouquetin des Alpes (Capra i. ibex) au cours de la saison de végétation sur le massif de Belledone-Sept Laux (Isère, France)*. Ph.D. thesis, University of Savoie, France, pp. 271 (2005).

2. P.J. Van Soest, *J. Assoc. Offic. Anal. Chem.* **46,** 829 835 (1963).

3. L. Thuriès, D. Bastainelli, L. Bonnal, R. Oliver, M. Pansu and C. Feller, *J. Near Infrared Spectrosc.* **13,** 187 (2005).